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ABSTRACTS FROM ASTRONOMICAL PUBLICATIONS.

In accordance with a recent arrangement the members of the scientific staff of the Lick Observatory hold meetings once per week, as an observatory duty, to report upon and discuss the more important articles appearing in the journals of astronomy, the important new books on astronomical subjects, or subjects of current and special interest in the observatory's work. It has been suggested that abstracts of the reports would be of interest to the readers of these Publications, and the Publication Committee has acted favorably upon the suggestion.

It is intended to preserve the qualities of abstracts as far as possible, and to restrict published criticisms, favorable or unfavorable, to a minimum.

SECULAR VARIATIONS OF THE ELEMENTS OF THE ORBITS OF THE FOUR INNER PLANETS COMPUTED FOR THE EPOCH 1850.0 G. M. T.

Under this title Professor ERIC DOOLITTLE presents a memoir, read before the American Philosophical Society on March 1, 1912, which embodies the results of his calculations on the general perturbations of the four inner planets—*Mercury, Venus,* the Earth, and *Mars*. The calculations are based on HILL's first modification of the method of GAUSS, and their purpose is to furnish a comparison of the results obtained by this method with those obtained by the usual method of expansion into an infinite series. The relative advantages of the two methods are stated in the introduction. The one, "based upon the development of the perturbing function into an infinite series whose successive terms involve continually higher powers of the eccentricities and the mutual inclination," has the advantage of simplicity when extreme accuracy is not required, and the further advantage that changes in the results produced by the substitution of improved values of any of the elements can readily be ascertained, as all of the coefficients in the expansions are general literal expressions. On the other hand, it has "the disadvantage that the complexity of the expansion grows rapidly greater as the order of the included terms is increased, so that a slight increase in the desired accuracy greatly increases the labor of the computation."

The integral methods, based on GAUSS's theorem, are free from this disadvantage, for terms of the twenty-fourth order can be included by a computation "less than twice as long as that required when the approximation is stopped at terms of the eleventh order." To offset this advantage of great accuracy, the method has the disadvantage that any computation leads only to numerical results based upon the assumed elements. If any of the elements are changed, the entire computation must be repeated.

The introduction gives a brief statement of GAUSS's method and of the essential features of the various modifications introduced in it by HILL and others. HILL's first modification was employed by DOOLITTLE in his computations, because he considers that this leads to the most accurate results when seven place logarithms are employed.

The main portion of the memoir gives the formulæ employed in the computation, the assumed values of the preliminary constants, tables of the radii vectores and of the true anomalies of the four planets, and finally the detailed results of the computed perturbations in the motion of each one of the four planets due to the attraction of the seven remaining planets taken in order. Thus the work embodies the results of twenty-eight series of computations. To insure accuracy in the numerical operations, check equations were used throughout, many of them devised by the computer himself, and where these were not available, the computations were repeated.

The results of these laborious calculations are then collected and compared with those obtained by LEVERRIER and NEWCOMB, the only other two complete series for the four inner planets which are in any sense modern ones. These are both based on the usual expansion into an infinite series, NEWCOMB's results being the more accurate.

The results are also compared with those derived by NEWCOMB from a discussion of all of the available observations of the planets and of the Sun. It is found that the theoretical values of the coefficients derived by the method of GAUSS are, in general, in excellent agreement with those computed by the method of infinite series, and the agreement with the observational results is only slightly improved except in the case of the node of *Mercury*, "where the residual is reduced by its fourth part."

The comparison of computed results with those based on observation also shows that the residuals are in general smaller than, or of the same order as, their probable error, except in three cases—viz., the motion of the perihelion of *Mercury*, the motion in the node of *Venus*, and the motion of the perihelion of *Mars*. In the second case the discordance is eight times, in the third between three and four times the probable error, and these uncertainties cannot be accounted for by uncertainties in the computation or in the assumed masses.

In the first case, the "well-known discordance," the difference is more than twenty times the probable error. It will be recalled that this discordance was formerly attributed to the perturbing action of a hypothetical planet between *Mercury* and the Sun, though some have assumed that it and certain other outstanding discordances indicated that the Newtonian law of attraction was not strictly accurate. The negative results of the search for *"Vulcan"* at the Lick Observatory Crocker eclipse expeditions of 1901, 1905, and 1908 have practically established its non-existence. But SEELIGER has explained the discrepancies by the perturbing influence of the clouds of particles which produce the Zodiacal Light. DOOLITTLE investigates this hypothesis and concludes that it "is capable of greatly reducing those discrepancies whose values are sufficiently large to establish their reality, without at the same time unduly increasing any of the smaller ones."

The memoir concludes with a bibliography.

R. G. AITKEN.

November 14, 1912.

TABLES FOR THE TRUE ANOMALY IN ELLIPTIC ORBITS.

These tables were compiled by FRANK SCHLESINGER and STELLA UDICK, and published as Number 17, Volume II, *Publications of the Allegheny Observatory*. They give the value of v, the true anomaly, to the hundredth of a degree for each degree of M, the mean anomaly, from 0° to 180°, and for each hundredth of e, the eccentricity, from 0.01 to 0.77 inclusive. The tables are arranged for convenient interpolation not only for the decimals of M, but also for the third decimal in e, for "successive values of v for the same value of M (but different value of *e*) are found in the same horizontal line." Great care was exercised in making the computations and in insuring accuracy in the printing, and it is believed that the tables have few if any errors.

The tables are, of course, designed only for use in cases where the accuracy required in the *v*'s does not exceed 0°.01,—as, for instance, in the computation of orbits for visual and spectroscopic binary stars. In such work they are very convenient and save a great deal of time, as the present writer can testify from his experience in using them.

R. G. AITKEN.

November 14, 1912.

PHOTOGRAPHIC MAGNITUDES OF THE SUN AND PLANETS.

"Photographic Photometry on a Uniform Scale" is the subject of Volume LIX of the *Harvard Annals*. The volume consists of ten numbers containing investigations by KING on subjects related to the general subject of the volume. The last number, which was received recently, gives the results derived from photographic observations of the Sun and planets for the purpose of determining their magnitudes.

Photographs of the Sun were secured with a pin-hole camera, in which the Sun's light was diminished by a combination of shade-glass and porcelain placed over the brass plate carrying the various-sized apertures of the camera. Each plate so exposed was then preserved until opportunity occurred for photographing on it the out-of-focus image of one of the three comparison stars — namely, *Polaris, Arcturus,* and *Capella.* From eleven observations the resulting photographic magnitude of the Sun is — 25.83. Applying the correction for the difference between the photographic and visual magnitudes of a star of spectral Class G, gives — 26.81 as the Sun's visual magnitude.

Out-of-focus images of the planets *Venus, Mars, Jupiter,* and *Saturn* were photographed with the Draper telescope; and for comparisons, a series of out-of-focus images of either *Polaris, Sirius,* or *Arcturus* were also photographed on the plates. The magnitudes deduced for the major planets all refer to the time of mean opposition, and for *Venus,* the magnitude is that which the planet has when its distance from the Earth and Sun is one astronomical unit. Accordingly, the observations must be corrected for distance and phase angle. The relation between phase angle and magnitude is usually expressed by the formula—

$$\text{Mag.} = A + B\alpha \quad (1),$$

where A is the magnitude when $\alpha = 0°$. This formula did not represent the observations of *Venus;* accordingly two others were tried, with better success—

$$\text{Mag.} = A + B\alpha^2 \quad (2)$$
$$\text{Mag.} = A + B \log \sec \tfrac{1}{2}\alpha \quad (3)$$

The photographic albedoes were computed from ZÖLLNER'S formula. The final results are brought together in the following table, where the photometric results of the Potsdam observers are given for comparison:—

	Harvard—		Potsdam—	
Planet.	Mag.	Albedo.	Mag.	Albedo.
Venus (1)	—2.56	0.66	—3.52	0.62
Venus (2)	—1.96	0.38	......	...
Venus (3)	—1.91	0.36	......	...
Mars	—0.57	0.15	—1.78	0.27
Jupiter	—1.78	0.80	—2.23	0.62
Saturn	+1.52	0.53	+0.41	0.50

In a preceding number of Volume LIX, the photographic magnitude of the full Moon is found to be —11.13. Knowing the Sun's photographic magnitude, the Moon's photographic albedo comes out 0.097, a result agreeing closely with visual determinations.

C. C. KIESS.

RESONANCE SPECTRA OF IODINE BY MULTIPLEX EXCITATION.[1]

This article deals with recent studies by Professor WOOD of the complicated phenomena presented by the fluorescence of iodine and some other vapors. In order adequately to carry on the investigation it was found necessary to construct, in addition to other pieces of apparatus, a grating of greater resolving power than any heretofore used, and that part of the paper which deals with the description and performance of this instrument is perhaps the one of most interest to the working astronomer. The practical resolving power of the instrument is such that lines .022 of an Ångstrom are clearly separated, while the theoretical resolution is .018 A.

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[1] R. W. WOOD, *Philosophical Magazine,* **24,** 673, 1912.

The construction and maintenance of the apparatus affords an excellent example of what can be accomplished in economy of material and the adaptation of the resources of a household to the requirements of scientific investigation. For instances, the grating pier was fashioned from a discarded water-pipe and the family cat was made to play its humble part by freeing the telescope tube of cobwebs. That the latter did its work effectively is shown by the wonderful definition of the spectrograms, which probably surpass in excellence any heretofore secured.

An interesting detail of the investigation is the use of a ray filter to screen out *certain portions of the bright lines* used, to excite fluorescence.

Professor WOOD's investigations of resonance spectra are most interesting and important, but in their present incomplete state are of more interest to the experimental physicist than to the astronomer. W. H. WRIGHT.

THE DIURNAL RANGE OF TEMPERATURE AND OTHER METEOROLOGICAL ELEMENTS AT DIFFERENT LEVELS ABOVE MOUNT WEATHER, VIGRINIA.[1]

The data for this study are being obtained by kites and captive balloons. A time is selected when the weather will probably be clear and the winds good for the following thirty-six hours, and a series of ascensions to a height of three kilometers, or a little more, above sea-level is made. The data from experiments so far made has been tabulated and charted so as to show the variation in wind, temperature, and electrical potential as recorded at elevations 0.5 kilometers apart.

Such data have a bearing upon the question of conditions for astronomical observation at various altitudes. Constancy of temperature being a desideratum in many classes of astronomical work, it is interesting to note that "the departures of the hourly temperatures from the mean for the day are less at a level between 1.5 and 2 kilometers (5,000 and 6,600 feet) than either above or below it." W. H. WRIGHT.

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[1] WM. R. BLAIR, *Physical Review*, **34**, 477, 1912.

APPLICATION OF THE SELENIUM CELL TO PHOTOMETRY.[1]

The paper covers a study of the properties of the selenium cell, under varying conditions of radiation and exposure, undertaken for the purpose of adapting such a cell to the requirements of spectro-photometry. Quoting Dr. PFUND: "The remarkable property possessed by selenium of changing its electric resistance upon illumination has led many investigators to construct photometric devices involving the use of a selenium cell. In spite of past efforts, however, the selenium cell has failed to establish itself in the field of exact photometry."[2]

In the experiments monochromatic light of varying wave-length was allowed to fall on the cell and the deflection of the galvanometer used to measure the changing resistance was noted. For the details of the observations and instrumental arrangement the original paper should be consulted. Calling D the deflection and E the energy of the exciting light, the following relation was found to exist:—

$$D = K E^B,$$

where K and B are constant as long as the wave-length of the exciting light remains the same. A remarkable fact is that B varies with the wave-length. Above 6500 A it has a value of 0.52 ±, while below 7000 A it is equal to unity. In other words, for blue, green, and yellow light the deflection of the galvanometer needle varies about as the square root of the intensity of the exciting light, while just below the red it is directly proportional to the intensity. From this it follows that for comparatively intense light the maximum of sensitiveness is just below the red, while for feeble illumination the sensitiveness is greatest in the yellow-green at about 5600 A. To this peculiar behavior of the selenium cell Dr. PFUND ascribes the apparently contradictory results arrived at by previous investigators. An accuracy of about two per cent was attained in the various determinations. This corresponds on the magnitude scale to about 0.02 magnitudes.

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[1] A. H. PFUND, *Physical Review*, **34**, 370, 1912.

[2] This statement reads somewhat strangely when we recall the remarkable success of STEBBINS in applying the selenium photometer to the discovery and measurement of minute variations in the light of variable stars. It may be that the author refers to exact *absolute* measurements, those of STEBBINS being differential.

The properties discovered by Dr. PFUND restrict the use of selenium photometer largely to the measurement of monochromatic radiations, for which purpose he considers it can be made a reliable instrument. He points out the difficulties in the way of adapting it to the measurement of "white light" and the necessity of callibrating the instrument, when so used, against the source to be studied. This is practically the procedure in the measurement of small variations in the light of a variable star, but even here the quantitative results can only be depended on when the variations are slight, since, in the state of our knowledge as Dr. PFUND leaves it, we have no method of integrating the sensibility curve. The reviewer is tempted to suggest that, where the intensity of illumination permits it, the rays above 7000 A might be screened out, since below this point the deflection of the needle is directly proportional to the wave-length, but it remains to be proved whether the integration of rays of different wave-lengths even in this region is a simple matter.

The remarkable application of Dr. STEBBINS to the measurement of very slight variations in the light of stars warrants an interest on the part of astronomers in the character of the sensibility curve, since it is a matter of great importance to know the effective region of the spectrum with which we have to deal. Dr. PFUND's work lays the foundation for a much more complete understanding of this subject than we have heretofore enjoyed. W. H. WRIGHT.

An unusually interesting spectrographic orbit is that of *β Scorpionis,* calculated by Dr. J. C. DUNCAN, and published in Lowell Observatory Bulletin No. 54. The spectra of both components of the system are visible; the period is 6.828 days, and the eccentricity 0.27. Dr. SLIPHER found in 1908 that the H and K lines of calcium in this star were very sharp and well-defined, and that, moreover, they did not share in the periodic oscillation of the other lines, an appearance first noted by HARTMANN for δ *Orionis* in 1904. The data of the spectrographic orbit depend upon lines of hydrogen and helium, and give for the velocity of the binary system as a whole — 8^{km} per second, while the sharp and unvarying calcium lines give a velocity of — 16.6^{km} per second, with a probable error of half a kilometer. This result may be regarded as tending to support the view that the calcium lines have their origin in something independent of the binary pair. H. D C.

THE DIAMETERS OF THE STARS.

This is a problem which has hitherto baffled all attempts at a solution by direct observation. What information we have on the subject has been in general derived from the analogy of our Sun, though some data of value have been derived indirectly from the probable dimensions of spectrographic binary systems and from the theory of eclipsing variable stars. Using the surface brightness of the Sun as a standard, PICKERING derived as the probable average apparent diameter of a sixth-magnitude star 0″.001, and about 0″.009 for one of the first magnitude, quantities which are of course far below the resolving power of any telescope.

In the *Astronomische Nachrichten*, **192**, 21, 1912,[1] Professor S. POKROWSKY gives the theory of a method for determining this dimension, depending upon the photometric measurement of the double stellar image secured by an apparatus for plane and elliptical polarization of the light of the star. The device is rather a complicated one; in theory it depends on the fact that the rays from a given point of a luminous body when received through two apertures not too close together, will show a certain phase difference depending on the distance of the body and the amount of separation of the apertures. For different points of a luminous body this phase difference will vary, the amount of the variation depending on the apparent angular diameter of the body. Neglecting certain compensating devices, the scheme proposes that two separate bundles of rays from a body are first plane polarized; one bundle is then rotated 90° and the two bundles combined into one, which should show elliptical polarization, unless the distant body is of infinitesimal size. Analyzing this elliptically polarized beam with a doubly refracting prism, two images of the body will be seen, and the measured difference of the intensity of these two images will give data for the determination of the angular diameter of the star. The magnitude of the star, and the loss of light in the apparatus enter as limiting factors. POKROWSKY assumes a loss of five per cent at each of the nineteen optical surfaces of the scheme, which is reasonable, but his estimate of a further loss of five per cent in transmission is evidently a slip; more probably such loss would amount to twenty or thirty per cent.

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[1] Translated in the September number of the *Astrophysical Journal.*

The limiting angular diameter which could be determined for a first magnitude star, according to POKROWSKY's formulæ, would be $0''.0048$; for stars of zero magnitude it would be $0.''0031$, while for *Sirius* it would descend to $0.''0017$. Taking into account the distance, the following would be the lower limit of measurable diameter for the following stars: —

α Centauri	580,000	miles
Sirius	400,000	"
Cord. Zones, 5^h 243	54,000,000	"

It should be mentioned that the method has yet to be tested. POKROWSKY points out that it would be very sensitive to atmospheric disturbances, and that the best place to try the method would be at a mountain observatory. H. D. C.

THE "HOLBROOK PEAS."[1]

On July 19, 1912, between 6:20 and 6:40 P. M., a large meteor was heard traveling east over Winslow, Holbrook, and Aztec, points on the Santa Fé Railroad, in Navajo County, Arizona. No meteor light was seen during the flight because of the twilight. The speed was related to have been "terrific," and the path was strewn with thin smoky vapor. The meteor made a loud noise, variously described as like the rumble of a wagon, escaping steam, and distant thunder. There was one large explosions and several small ones. Two persons saw stones fall at Aztec, raising puffs of dust for a mile or more over the dry sand of the desert. They report them to have been too hot to pick up. The stones were found scattered indiscriminately without regard to size, over an ellipsoidal area roughly estimated to be about one-half mile wide and three miles long. As frequently recorded in meteoric falls, the longest diameter of this ellipsoid was in line with the west to east trajectory of the meteor. Most of the fragments lay on top of the loose sandy soil. The large pieces sank one to six inches slantingly. Most of the stones have been acquired by the Foote Mineral Company of Philadelphia, where they have been examined. The body was an aërolite containing less than 4 per cent of nickel-iron and 96 per cent of silica. The total number of fragments is estimated as more than fourteen thousand.

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[1] From the *American Journal of Science* for November, 1912.

A record of the more notable stone showers of the nineteenth century is presented below. Such showers are rare and the number of the "Holbrook Peas" is one of the largest. They are distinguished by their minute size. The smallest average ten thousand to the kilogram. A single one weighs less than 0.1 gram, being smaller than the smallest of the Hessle stones, which were found only because they fell on ice.

PRINCIPAL STONE SHOWERS OF THE NINETEENTH CENTURY.

From Wülfing's "Meteoriten."

Date.	Locality.	Number.	Quantity.
1803 April 26	L'Aigle, France	2,000-3,000	36^k
1807 Dec. 14	Weston, Conn.	....	18
1808 May 22	Stannern, Austra	200-300	38
1860 May 1	New Concord, Ohio	30 +	97
1866 June 9	Knyahinya, Hungary	1,000 +	423
1868 Jan. 30	Pultusk, Poland	100,000 ±	201
1869 Jan. 1	Hessle, Sweden	....	22
1875 Feb. 12	Homestead, Iowa	....	124
1882 Feb. 3	Möcs, Hungary	100,000 +	155
1890 May 2	Forest, Iowa	....	122
1912 July 19	Holbrook, Arizona	14,000 +	218

No other aërolites are recorded from Arizona, the nearest meteoric fall being the siderite of Cañon Diablo.

Perseids and *Aquaris* closely follow the date of the Holbrook fall, but it cannot be clearly identified with them.

G. F. P.

THREE NEW SPECTROGRAPHIC ORBITS.[1]

γ *Geminorum*.—Period nearly six years; eccentricity, 0.3; computed by W. E. HARPER. This period is a little longer than the shortest visual binary period. The orbit is in doubt because several observations made at Lowell Observatory in 1902 and 1903 and others at Potsdam in 1910 do not agree with it. This period may be found inapplicable, or possibly it may be found to be a multiple of the actual period.

ζ *Persei*.—Period, seven days; orbit, nearly circular, deduced from the H and K calcium lines alone, which give an amplitude of oscillation of 15^{km}. Other lines are too diffuse for orbit computation, but have a greater amplitude of oscillation.

θ^2 *Tauri*.—Period, 140.5 days; eccentricity, 0.7. This eccentricity is one of the highest among spectrographic orbits. This star belongs to the Boss *Taurus* stream. A difference of three or four kilometers is found between the velocity of this binary system and the velocity computed for it in the discussion of the stream motions.

G. F. P.

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[1] *Journal of the Royal Astronomical Society of Canada*, May-June and July-August, 1912.